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"Innovation and demand in industry dynamics"

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Innovation and demand in industry dynamics

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Abstract

The links between three interconnected elements of the Schumpeterian sources of economic change are explored, conceptually and empirically, in this paper: the commitment of industries to invest profits in cumulative R&D efforts; the ability of industries' R&D to lead to successful innovations; the impact of new products and processes on high entrepreneurial profits. We consider the nature and variety of innovative efforts – distinguishing in particular between strategies of technological and cost competiveness – and we introduce the role of demand in pulling technological change and supporting profits. We develop a simultaneous three-equation model and we test it at industry level – for 38 manufacturing and service sectors – on eight European countries over two time periods from 1994 to 2006. The results show that the model effectively accounts for the dynamics of European industries and highlights the interconnections between the different factors contributing to growth.

Keywords: *R&D, Innovation, Profits, Demand, System Three Stages Least Squares*

JEL classification: *L6, L8, O31, O33, O52*

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1. Introduction[1]

Economic change in advanced countries can be seen – in a Schumpeterian perspective - as the result of three processes that are closely interconnected. First, the cumulative nature of knowledge and R&D, supported by *technology push* and *demand pull* factors, and linked to the commitment of firms and industries to invest profits in research activities. Second, the ability of industries' R&D to lead to successful innovations, combining developments both on the supply and on the demand side . Third, the impact on entrepreneurial profits of new products, new processes, and demand growth.

This article explores these complex relationships and investigates the links between innovation and economic performance in an integrated perspective. Much economic research has investigated these issues either considering externalities and spillovers as major channels for the diffusion of knowledge and technologies, or focusing on R&D driven technological change that leads to endogenous growth. We aim to enlarge the picture, considering the *diversity* of innovative efforts – that include not just R&D, but also innovative investment, adoption of new technologies, learning processes, etc. -, the *uncertainty* of technological change – addressing innovative *outputs* as well as *inputs*, such as R&D – and the *feedback* effects that may exists among the different relationships.

A few contributions have explored the links between innovation and economic performance by breaking down this sequence and estimating empirically different phases: the decision to invest in R&D, the relationship between input ad output and the effect of R&D on economic performance (Crépon et al. 1998 and Parisi et al. 2006). In a recent work (Bogliacino and Pianta, 2010b) we develop a model with a three-equation system that explains R&D intensities, the importance of new products in sales and the growth of profits; an empirical test is carried out at the industry level for major European countries. We find that R&D supports successful innovations and that they lead to higher profits, which in turn finance R&D, with a complex structure of lags and feedbacks.

In this article we provide two main novelties. First, we integrate the analysis of the innovation-performance link with the demand side, exploring the role of different demand factors – exports, domestic consumption, intermediate demand, etc. - in the equations. Second, we consider the determinants of product innovations, that reflect a strategy of *technological competitiveness*, and we investigate in parallel the impact of process innovations and acquisition of new machinery, associated to a search for *cost competitiveness.*

The article proceeds as follows. Section two presents the model; section three data and methodology, section 4 the results and section 5 the concluding remarks.

2. The relationships between R&D, innovation and profits

We estimate a system of equations that account for R&D efforts, product innovation and profits growth. In the following subsections we put forth the theoretical basis of each part of analysis and we discuss the points of contact with the existing literature.

2.1. The decision to carry out R&D efforts

We follow the evolutionary theory of R&D efforts by firms. R&D is a path dependent process because the paradigm (and trajectory) related development of technology makes the process of search eminently localized (Atkinson and Stiglitz, 1969; Nelson and Winter, 1982; Dosi, 1982 and 1988).

[1] This article develops the paper presented at the 13th International Schumpeter Society conference in Aalborg; for the discussion there we thank (in alphabetical order) Kenneth Carlaw, Giovanni Cerulli, Giovanni Dosi, Marco Grazzi, Marco Valente and Syd Winter; a special thank to our discussant Thorbjorn Knudsen. We are indebted to Matteo Lucchese for help with data. The usual disclaimer applies. The views expressed are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.

R&D is affected by demand pull (Schmokler, 1966; Scherer, 1982) and technology push effects (Mowery, 1979). According to the former perspective, innovation is brought to the market when firms anticipate strong demand; in the latter view innovation is supported by by science related developments and is triggered by relative prices in a feasible production set. Moreover, innovation is persistently characterized by the presence of specific technological and production capabilities (Pavitt, 1984; Dosi, 1988; Malerba, 2005; Metcalfe, 2010).
Finally, R&D may be cash constrained (Hall, 2002) due to the intangible nature of R&D which is difficult to collateralize and due to informational problems, namely the "radically uncertain" nature of research and the asymmetric distribution of information in the classical lender-borrower case (Stiglitz and Weiss, 1981). Under these conditions, profits from past innovation play a major role in financing R&D. Our first equation is the following:

$$R\&D_{ijt} = \alpha_0 + \alpha_1 R\&D_{ijt-1} + \alpha_2 DP_{ijt} + \alpha_3 CAP_{ijt} + \alpha_4\ \pi_{ijt} + \varepsilon_{ijt} \qquad (1)$$

where, from now on, *i* indicates industry, *j* country, *t* time. R&D is research and development, DP stands for *demand pull*– related to the potential for the introduction of new products -, CAP for a measure of capabilities, π represents profits and the last term is a standard error term. In section 3.2 we discuss the proxies used from our database.
Our model builds on the large literature on the determinants of R&D. A first strand of literature tried to detect an effect of size on the amount invested (Cohen and Levin, 1989; Cohen, 2010). This line of research has been criticized for being unclear on whether it is innovation input or output that is affected by size and for the risk of endogeneity, given that both market structure and innovation are codetermined by the fundamental features of the sector (appropriability, cumulativeness and the knowledge base, see Breschi et al. 2000).
The *demand pull* versus *technology push* debate led to several contributions that include both factors and control for the capabilities. Kleinknecht and Verspagen (1990) find a significant effect of demand after controlling for path dependency. Piva and Vivarelli (2007) estimate demand pull effect for different groups of firms; the effect of demand is higher for firm which export, do not receive public subsidies, are liquidity constrained, diversified, large and in medium and low tech sectors. Bogliacino and Gómez (2010) found a negative and significant effect of the distance from the production frontier, which is proxy for technological capabilities. A more recent strand is the one related with the use of Innovation Surveys (for a review see Mairesse and Mohnen, 2010) which in general underline a positive role of size and public support to innovation.
The importance of profits in supporting innovation was pointed out by Schumpeter[2] but has led to a limited literature; studies on financial constraints in R&D investment are reviewed by Cincera and Ravet (2010). In their empirical exercise, they found that cash constraints are important for EU but not US firms, using data from the R&D Scoreboard which covers the largest R&D investors. Their argument is indirectly supported by Brown et al. (2009) who found that the "dot.com bubble" played a major role in allowing R&D expenditure growth in the US in the 1990s. Finally, Bogliacino and Pianta (2010b) - which is the most direct reference for our work - found a positive effect of capabilities and a positive effect of profits from past innovation.

2.2. Explaining product innovation

Economic change is shaped by successful innovations, rather than by R&D inputs. For this reason several models – such as Crépon et al. (1998), Parisi et al. (2006) and Bogliacino and Pianta (2010b) -

[2] "Whence come the sums needed to purchase the means of production necessary for the new combinations if the individual concerned does not happen to have them? (...) By far the greater part (...) consists of funds which are themselves the result of successful innovation and in which we shall later recognise entrepreneurial profit" (Schumpeter*,* 1955,71-72).

add a second equation on the relationship between innovation inputs and outputs. The conceptualisation of innovation is important in this context; a huge evolutionary literature has pointed out the role of different modes of innovation depending on the technological trajectory associated with each sector (Pavitt, 1984; Dosi, 1988; Malerba 2002 and 2004 among the others). Pianta (2001) suggested to return to the original Schumpeterian distinction between product and process innovation; although they often are complementary, they are usually associated with different objectives and generate different effect in terms of growth, employment and distribution (see Crespi and Pianta, 2007, 2008a, 2008b; Pianta and Tancioni, 2008; Bogliacino and Pianta, 2009, 2010a) and should be kept analytically distinct. The concepts of *technological* and *cost competitiveness* have been proposed to summarise on the one hand innovation strategies focusing on new markets, new products and R&D, as opposed to efforts directed at labour saving new machinery, efficiency gains and cost reductions, respectively.

Efforts for cost competitiveness and process innovation can be directly measured by the adoption of new machinery and equipment, and have an immediate effect on economic performance; we therefore include the cost competitiveness variable in the economic performance equation (equation 3 below). Technological competitiveness and product innovation, on the other hand, are dependent on many factors (research outcomes, elasticity of demand, market structure, etc). Accordingly, we introduce a second equation where technological competitiveness – expressed by the importance of product innovations - is determined by R&D, market structure and demand.

Our second equation is the following:

$$TC_{ijt} = \beta_0 + \beta_1 R\&D_{ijt-1} + \beta_2 D_{ijt} + \beta_3 MS_{ijt} + \varepsilon_{it} \qquad (2)$$

where TC stands for technological competitiveness, R&D is the variable predicted by equation (1), D stands for one or more variable for demand and MS is a measure of market structure.

Successful innovation leading to new products and new markets requires R&D inputs and - as in the Schumpeterian "mark II" models – is often characterised by the presence of large firms with strong capabilities for exploiting knowledge, and oligopolistic market structures, where high incentives to generate product innovations exists. Finally, demand may play a role in several ways. The *demand pull* perspective and the literature on structural change (Pasinetti, 1981) emphasise the positive effect that a strong demand dynamics has on the development and diffusion of new products. This is a complementary approach to the Schumpeterian analysis of the way major innovations change the economy. However, when an economy – or an industry - operates in the Schumpeterian "circular flow", without major innovations, current demand for standard products may reduce the incentive to develop new products and delay their introduction. Therefore, demand that matches relevant technological change – the most dynamics components of demand, such as exports – is likely to support the introduction of new products in a virtuous circle between capabilities, innovations and markets (as in "learning by exporting" hypothesis, see Crespi et al. 2008). Conversely, demand that is related to the activity of industries where a "circular flow" prevails – such as demand for consumption and for intermediate goods –may lead to less incentives for the introduction of new products.

Recent studies have tried to explore the relationships of equation (2) usually using patents as a measure of product innovation[3]. A review can be found in Denicolò (2007), who suggests that 0.7-1.0 can be a good measure of the elasticity of product innovation to R&D.

2.3. Explaining the dynamics of profits

Following Bogliacino and Pianta (2010b), we add a third equation for the dynamics of profits. We depart from previous work such as Crépon et al. (1998) and Parisi et al. (2006), where the performance

[3] It is widely discussed in the literature that patents are a biased indicator and capture very poorly the innovation output outside Science Based industries (for a discussion on measuring innovation, see Archibugi and Pianta, 1996 and Smith, 2005).

equation explains productivity growth. These contributions use productivity because, at the firm level and with a short time dimension, any measure of profits is likely to be highly volatile. Our use of industry level data and our time structure (larger and based on long differences as discussed below) allows using stable indicators of profit growth as the most appropriate measure of industry performance.

In our formulation, profits are affected by supply and demand factors. On the supply side profits are supported by successful efforts to achieve both technological and cost competitiveness; the former is the variable – importance of product innovation – resulting from equation (2); the latter is the outcome of technology adoption and investment in new machinery. On the demand side, a strong growth of production and sales may reflect sustained demand for an industry's output. Our third equation of the system is the following:

$$\pi_{ijt} = \gamma_0 + \gamma_1 TC_{ijt} + \gamma_2 CC_{ijt} + \gamma_3 D_{ijt} + \varepsilon_{ijt} \qquad (3)$$

where TC and CC are technological and cost competitiveness as defined above, and D stands for demand – proxied in this case by growth of industry sales.

The literature on the determinants of profits and on the impact of innovation is rather thin (Teece, 1986, Geroski, Machin and Van Reenen, 1993, Cefis and Ciccarelli, 2005, Pianta and Tancioni, 2008; Bogliacino and Pianta, 2010b) and has generally found a significant effect of all types of innovation on profits.

3. Data and methodology

3.1. Data

In the empirical analysis we use industry level data from the Sectoral Innovation Database (SID, University of Urbino, 2007) that includes data from three European Community Innovation Surveys - CIS 2 (1994-1996), CIS 3 (1998-2000) and CIS 4 (2002-2004) – matched with data from OECD-STAN for production (that we use as a proxy for sales), value added, employment and operating surplus and data from OECD Input-Output Tables to calculate demand components. Data are available for the two-digit NACE classification for 21 manufacturing and 17 service sectors; all data refer to the total activities of industries.[4]

The country coverage of the database includes six major European countries – Germany, France, Italy, Netherlands, Spain, and United Kingdom - that represent a large part of the European economy. The selection of countries and sectors has been made in order to avoid limitations in access to data (due to the low number of firms in a given sector of a given country, or to the policies on data released by national statistical institutes).

Time periods are the following. Economic and demand variables are calculated for the periods 1995-2000 and 2000-2005. Innovation variables refer to 1994-1996 (used for the lagged R&D variable in equations 1 and 2); 1998-2000 (linked to the first period of economic variables); 2002-2004 (linked to the second period of economic variables). The variables used are listed in Table 1.

[4] CIS data are representative of the total population of firms and are calculated by national statistical institutes and Eurostat through an appropriate weighting procedure. Economic variables are deflated using the GDP deflator from Eurostat (base year 2002) corrected for PPP (using the index provided in Stapel et al. 2004).

Table 1. List of variables from the SID Database

Variables	Unit	Source
In-house R&D expenditure per employee	Thousands euros/empl	CIS
New Machinery expenditure per employee	Thousands euros/empl	CIS
Share of product innovators	%	CIS
Share of firms innovating with the aim to open new markets	%	CIS
Average firm size	Number empl per firm	CIS
Compound rate of growth of Export	annual rate of growth	Eurostat
Compound rate of growth of Intermediate Demand	annual rate of growth	Eurostat
Compound rate of growth of Household Final Demand	annual rate of growth	Eurostat
Distance in Labour Productivity from the Frontier	%	Elaboration from STAN
Compound rate of growth of Production	annual rate of growth	STAN
Compound rate of growth of Operating Surplus	annual rate of growth	STAN

In order to use these data in panel form, we need to test that the sample design or other statistical problems in the gathering of data are not affecting the reliability of data. Besides considering the time-effects capturing macroeconomic dynamics, we have examined the stability of the database. A very detailed empirical investigation on the characteristics of the database has been carried out in Bogliacino and Pianta (2009a). We report in the following Table the main descriptive statistics:

Table 2. Descriptive statistics

Variables	Mean	SD Overall	SD Between	SD Within
In-house R&D expenditure per employee	2.66	4.89	4.10	2.06
New Machinery expenditure per employee	1.78	2.68	2.31	1.74
Share of product innovators	36.66	20.36	18.98	9.18
Share of firms innovating with the aim to open new markets	32.14	20.04	16.80	11.57
Average firm size	223.72	455.35	357.10	278.42
Compound rate of growth of Export	6.39	16.81	11.09	12.64
Compound rate of growth of Intermediate Demand	3.01	7.20	5.10	5.09
Compound rate of growth of Household Final Demand	2.64	10.67	6.64	8.49
Distance in Labour Productivity from the Frontier	29.84	22.14	20.57	8.27
Compound rate of growth of Production	2.92	5.51	4.15	3.71
Compound rate of growth of Operating Surplus	2.57	15.43	15.57	8.62

3.2. Methodological issues

We address the problem of endogeneity in three ways. First of all, we estimate the model by Three Stages Least Squares (3SLS) in order to explicitly model the endogenous variables and to control for simultaneity. Secondly, we use the time structure; we introduce lags whenever we have a suspect of endogeneity. Since our time lags are of three to four years, the autoregressive character (and the implied endogeneity) is considerably softened. Third, our use of average growth rates is equivalent to the use of long (log) differences which is a standard way in the literature to address the problem of endogeneity (see Caroli and Van Reenen, 2001 and Piva et al. 2005), besides removing individual time invariant effects. Finally the variables that are not expressed as rates of growth are scaled by the number of employees or firms (the ones expressed as shares), so we are correcting for the potential bias deriving from using groups of unequal size.

Our specification of the model is based on the choice of the following variables.

The R&D equation. The lag of R&D per employee accounts for path dependence and cumulativeness of knowledge. Technology push effects are likely to be internal to the sector, or controlled for by the autoregressive nature of R&D. As a proxy for *demand pull* effects we use the share of firms which innovate to expand the range of products, reflecting expectations on the presence of strong demand for new and improved goods and services.[5] As a proxy for capabilities we use the distance in percentage points from the labour productivity of the industry in the country where the productivity is the highest.[6] Closeness to the frontier indicates accumulated capabilities and a greater need to carry out R&D as the opportunities for imitating leaders are modest; in this case a negative relationship is therefore expected. Finally, the rate of change of profits is proxied by the operating surplus.

The product innovation equation. In order to explain the relevance of technological competitiveness, as dependent variable we use the share of firms that have introduced a product innovation (with or without the parallel introduction of new processes). Lagged R&D per employee has been defined above. The structure and dynamics of demand is measured as the change in demand for goods produced by the industry (calculated from input-output tables), and is accounted for by different variables: the most dynamic component of demand is the rate of change of export, that is expected to have a strong positive impact on the new products introduced by industries; the rate of change of household final demand and the rate of change of change of intermediate demand for the industry's output may be associated to standard products and may delay the introduction of new ones. Finally, as a measure of market structure we use the average size of firms in the industry: unfortunately it is not possible to have a concentration index at industry level for all manufacturing and service sectors.

The profit equation. The share of product innovators in the industry, defined above, is again the proxy we use for accounting for technological competitiveness. The innovation-related expenditure for new machinery per employee is the proxy we use for cost competitiveness. In order to account for the demand dynamics of industries we use the rate of growth of production, reflected in industry sales.

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[5] We use a variable of objective and not a direct measure of demand for two reasons: first, given the time lag necessary to obtain results from R&D, putting a contemporaneous term would be meaningless; second, the inclusion of a future term would be seriously affected by endogeneity problems and would have implied some form of rational expectations which are unrealistic in a radical uncertainty domain.

[6] See Bogliacino and Pianta (2010b) for a discussion of this variable. For every individual (sector-country) we calculate the labour productivity (value added per employee) in the initial year of the sub-period. Then for each industry we individuate the leader (e.g. for sector x1 the highest labour productivity is in country y2) and we compute the distance in percentage points. At the industry level this variable may be affected by the pattern of countries' competitive advantages; unfortunately with our dataset it is the only available measure.

4. Results

In the OLS estimation we do not find any particular diagnostic problem, in particular multicollinearity is not an issue: computing the variance inflation factors we found 1.06 for the first equation, 1.14 for the second and 1.21 for the third one. We therefore estimate the system with 3SLS as explained above.
We first report the result for a baseline estimation in which we do not control for demand. This baseline equation is a good term of comparison with Bogliacino and Pianta (2010b). The results are reported below in Table 3.

Table 3. The System: Baseline Formulation
Three Stage Least Squares. S.e. in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%. Source: SID

	(1) R&D per employee	**(2) Share of Product Innovators**	**(3) Rate of growth of profits**
R&D per employee (First lag)	0.46	2.69	
	[0.06]***	[0.28]***	
Rate of growth of profits	0.18		
	[0.07]**		
New Market Objective	0.07		
	[0.03]**		
Distance from the frontier	0.01		
	[0.02]		
Share of Product Innovators			0.38
			[0.10]***
New Machinery per employee			0.82
			[0.36]**
Rate of growth of sales			0.50
			[0.20]**
Constant	-0.92	24.80	-14.13
	[1.49]	[1.42]***	[3.30]***
Obs	204	204	204
RMSE	5.27	16.07	17.71
Chi-2	130.80	86.48	38.45
(p-value)	(0.00)	(0.00)	(0.00)

In the first equation, as expected, R&D is path dependent, is pulled by demand, and is finance constrained, with profits playing a supporting role. The only coefficient that does not meet our expectation is the distance from the frontier which is not significant (but we mentioned its weaknesses). In the second equation product innovation is driven by lagged R&D. In the third equation product innovation and the adoption of new technology, together with sales growth, explains the variance of the growth rate of profits.
These results are consistent with those found in our previous version of the model (Bogliacino and Pianta, 2010b). In order to have a full consideration of the role of demand, we now test the augmented version of our model, including the variables for market structure and demand in the second equation; the results are displayed in Table 4.

Table 4. The System: The Augmented Version with Demand and Market Structure.
Three Stage Least Squares. S.e. in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%. Source: SID

	(1) R&D per employee	(2) Share of Product Innovators	(3) Rate of growth of profits
R&D per employee (First lag)	0.53 [0.06]***	2.71 [0.28]***	
Rate of growth of profits	0.19 [0.04]**		
New Market Objective	0.06 [0.02]***		
Distance from the frontier	-0.00 [0.01]		
Size		8.95 [5.38]*	
Rate of growth of export		0.40 [0.16]**	
Rate of growth of final consumption		-0.23 [0.09]***	
Rate of growth of intermediate demand		-0.59 [0.17]***	
Share of Product Innovators			0.35 [0.09]***
New Machinery per employee			0.72 [0.38]*
Rate of growth of sales			0.51 [0.19]**
Constant	-0.92 [1.49]	24.80 [1.42]***	-12.71 [3.19]***
Obs	204z	204	201
RMSE	5.30	15.36	17.71
Chi-2	198.91	127.90	35.36
(p-value)	(0.00)	(0.00)	(0.00)

The estimated coefficients come out as expected. In the R&D equation we have no particular change with regards to the previous estimation; past R&D and profits support R&D efforts, that are pulled by the perception of a potential market for new products; the distance from the frontier variable continues to be non significant.

In the product innovation equation, past R&D and firm size have a positive and significant impact, confirming the assumptions of the "Schumpeter mark II" perspective. Demand variables have, as expected, different effects on new products. Export growth is associated to a higher presence of product innovators, in line with the "learning by exporting" hypothesis (Crespi et al. 2008); a high growth of intermediate and consumption demand, conversely, is associated to lower product innovation – a typical case in "traditional" industries and services with little R&D, more standard goods and less international openness.[7]

In the profit equation again we confirm the finding of the baseline model. Profits are pushed in parallel

[7] A systematic analysis of the links between innovative dynamics, demand factors and structural change is in Lucchese (2010).

by innovation-driven gains in technological and cost competitiveness, and are pulled by demand-led growth in sales.
In order to check the robustness of our estimations, we address three potential problems: (a) size may be important also in explaining the decision to do R&D, (b) our specification may not control adequately for technology push, (c) there may exist omitted institutional factors at country level.
The relation between size and R&D has been addressed by a large literature that, however, did not lead to clear cut results; we run estimations adding size among the explanatory in the R&D equation, but it did not come out significant.
To address point (b) we also included time dummies in the R&D equation, but the results are unchanged, and the dummies are not significant. Indeed, the use of long differences, industry level data, average rate of change and autoregressive specification is a satisfactory strategy to account for time varying production possibilities frontier.
Finally, institutional differences are mainly accounted for through national level fixed effect. Since we are considering rate of changes, we are implicitly controlling for them. In any case, when we ran the estimation with country effects in all the three equations, we did not find any appreciable change in the results.[8]

5. Conclusions

Our model and the empirical results we obtain – focusing on the industry level - appear capable to account for important dimensions of the interconnected engines of economic change in a Schumpeterian perspective. Our three equation system links several insights of the evolutionary literature on innovation and supports them with its results.
In explaining R&D intensities, the cumulative nature of research and knowledge, the *demand pull* effect of the perceived potential for new products, and access to finance through the reinvestment of fast growing profits play a significant role.
In explaining the importance of product innovation, the same cumulative nature of R&D and firm size are important on the supply side, while demand factors either stimulate the introduction of new products, in the case of strong export growth, or may delay it when consumption and intermediate demand characterise industries' markets.
In explaining the dynamics of profits we find a direct effect of the previous variable - the importance of product innovation, reflecting a strategy of technological competitiveness – in addition to significant effects of gains in cost competitiveness – through process innovations introducing new machinery. Moreover, fast growing sales reflecting demand growth also contribute to higher increases of profits.
Three improvements on the existing literature emerge from our model and findings.
First, we provide a simultaneous explanation of three interconnected sources of change in advanced economies – R&D, product innovation and profits. We move from one-way relationships to a system that accounts for simultaneous links and feedback effects, developing Schumpeterian insights and providing support for several evolutionary assumptions. In this article we expand the model and test developed in Bogliacino and Pianta (2010b), extending the approach in new directions; the results confirm the strength of the model and the relevance of the empirical findings.
Second, while much of the evolutionary literature neglects the role of demand, we integrate – in our industry-level analysis - both technological and demand factors, showing that innovation in products and profits are deeply affected – in a complex way - by demand factors. In order to test these relationships we have built a major database that combines innovation survey and economic data with

[8] Technically, the identification of country effects is not possible: since our unit of analysis is the industry, which are in fixed numbers, the only way to increase the number of individual is by increasing the number of countries. Asymptotically the number of country effect diverges at the same rate as the sample size, thus we would face an incidental parameter problem. As a result, we do not report these estimations. All the three robustness check regressions are in any case available from the authors upon request.

a rich information on demand dynamics drawn from input-output tables for both manufacturing and service industries.
Third, our findings confirm the importance of the diversity of innovative efforts – pointed out by evolutionary approaches - and the strength of our previous work on the distinction between technological competitiveness (based on new products) and cost competitiveness (based on new processes) (Pianta, 2001).
These appear as important directions for both conceptual and empirical work aiming to explain in a comprehensive way the complex dynamics of economic change in advanced economies.

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